

Appl. No. 09/736,266

Amdt. dated July 13, 2005

Reply to Office action of Jan. 14, 2005

REMARKS/ARGUMENTS

Reconsideration of the application is requested.

The claims have not been amended.

We first address the rejection of claim 47, 59, 65, 67, and 68 as being anticipated by Harada (U.S. 5,233,260) under 35 U.S.C § 102(b). We respectfully traverse.

The rejection over Harada was previously discussed and the discussion led the Examiner to withdraw the rejection. We still believe that the claims are patentable over Harada and that our previously presented argumentation is fully valid. Our remarks concerning Harada in the amendment filed February 12, 2004 are herewith incorporated by reference. Specific reference is also had to the definition of "monolithic." As explained on pages 13 and 14 of the amendment of February 12, 2004, we define the monolith as:

a uniform or solid massive and undifferentiated whole that exhibits solid uniformity and often does not show diversity or variability.

We define in 47 a piezoelectric device, which is formed of a monolithic multilayer stack. The monolithic stack is formed with greenfoils of ceramic layers and an electrode layer with

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copper in between. By definition, a monolithic multilayer stack cannot have been formed by first sintering individual ceramic "layers," then placing electrode material on the outer surfaces of the sintered (i.e., fired) ceramics, and then pressing the sintered ceramic layers together with the electrode in between. By definition, a monolithic stack defines a uniform or solid massive and undifferentiated whole that exhibits solid uniformity - which definition cannot be read on stacks of sintered layers.

We respectfully remind the Examiner that this line of argumentation and our reliance on the word "monolithic" in claim 47 most likely formed the primary reason for the withdrawal of the rejection over Harada.

We once more summarize the differences between the claimed invention and the prior art. Harada stacks finished sintered piezoelectric ceramic layers on top of one another. See, for instance, col. 4, lines 64 - 68. Then the metallized layers are pressed together and subjected to heat and mechanical connection pressure. The metallization of the ceramic, therefore, is effected after the sintering of the ceramic material.

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As previously pointed out, this, of course, is not only the essence of the distinction between Harada and the claimed invention, but also the essence of the distinction between Harada and Harada's prior art. That prior art, as described in col. 1, line 65, had piezoelectric multistack components manufactured by commonly sintering greenfoils with inner electrodes of a silver palladium alloy commonly and simultaneously at a high temperature of 1300°C. Low-cost metals, such a Cu (melting temp. 1083°C) could not be used.

Harada's prior art, of course, is also different from the instantly claimed invention in that Harada's prior art utilizes different material for the inner electrodes. As pointed out several times before, one important object of the instantly claimed invention is that we render it possible for the first time to provide a true monolith that can do with a relatively inexpensive inner electrode material.

In describing the claimed invention, one may say that the term "monolithic" as it is used herein means that individual green foils are connected to one another with common sintering. The resulting monolithic piezoelectric actuator is a structure of several "cofired" layers that result in a monolith.

The instantly claimed invention is not anticipated by Harada.

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We now turn to the art rejection in which several claims have been rejected as being unpatentable over a combination of five references, namely, over Harada with Seo, Tsunooka, Dawson, and Horikawa und 35 U.S.C § 103. We respectfully traverse.

The primary reference Harada fails for the same reasons as outlined in the foregoing. The secondary references do not provide any teaching which would cure the error in the Harada rejection. We do not disagree with the Examiners summary of the secondary references, namely, that Seo discloses piezoelectric material which utilizes rubber in a polymer binder mix, that Tsunooka provides information concerning an advantageous piezoelectric composite material, that Dawson provides for submicron ceramic powder of perovskite compounds and that Horikawa shows a monolithic piezoceramic part that is apparently formed as a monolith.

The secondary reference Seo discloses that urethane rubber forms a part of the piezoelectric materials. In order to understand this teaching, one needs to briefly review the object of the reference Seo. There, a piezoelectric material is described which comprises anorganic and organic piezoelectric materials in the finished product. See col. 1, lines 43 - 49. The reason for this is that a highly flexible

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piezoelectrically isotropic material is to be provided where the organic components do not only provide for a temporary formability - as it is possible in green foil technology - but permanent formability of the finished product. These same organic components are then supposed to also influence the piezoelectric characteristics.

It follows, then, that Seo does not remove the organic components, which, of course, is very much in contrast with the instantly claimed invention, where a multilayer stack is disclosed from which the organic binders have been removed. In contrast, Seo describes in col. 2, line 35 that the urethane caoutchouc forms a polar part of the organic component as a permanently present component in the piezoelectric material.

Seo, therefore, does not describe either debinding or sintering the ceramic. One can certainly not find any hint towards a thermohydrolytic process for debinding (i.e., essentially without oxygen) in Seo as it is necessary for the prevention of copper oxidation. The only temperature treatment found in Seo is effected between 30°C and 100°C and it serves to polarize the final material. See col. 4, lines 14 - 26. Seo, it is respectfully submitted, is not useable in the context of the claimed invention in which ceramic green foils

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with intermediate copper electrodes are sintered to a common monolithic mass.

The component according to the claimed invention (as well as in Horikawa) utilizes a binder to add to the piezoelectric ceramic for the formation of green foils and, following the stacking of the green foils, it is fired out of the green foils.

The secondary reference is therefore not properly useable in combination with the references Harada or with Horikawa. Neither combination can suggest a process in which a binder in a multistack element is thermohydrolithically decomposed or removed in order to prevent the oxidation of metallic copper on the one hand and the sufficient sintering temperature for a proper densification of the ceramic material in order to lead to a monolithic ceramic multilayer stack.

The rejection is in error, however, not only because of the incompatibility of Seo with Harada (and of Seo with the claimed invention), but also because of the apparent misinterpretation of the secondary reference Horikawa. The Examiner is respectfully urged to review the following discussion of the Horikawa reference in light of the above-

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noted five-reference combination and the two-reference combination of Horikawa with Harada.

This brings us to the rejection of several claims as being unpatentable over Horikawa and Harada under 35 U.S.C § 103.

As properly summarized by the Examiner, Horikawa produces a monolithic piezoelectric ceramic part where green sheets are laminated and internal electrode layers are formed and the laminated stack is then sintered to lead to a monolithic component. As also correctly stated by the Examiner, Horikawa does not "disclose that copper is used as the internal electrode material."

In order to understand the fact that Horikawa fails to specifically disclose that copper is used and also that Horikawa in fact does not have copper internal electrodes one must review the reference teaching a little more closely.

First of all, Horikawa does not at all provide detailed information concerning the sintering process. One must therefore assume - and this is what a person of ordinary skill in the art will understand from the Horikawa teaching - that no specific preparations are made and that sintering is, as usual, effected in regular ambient atmosphere. Such standard

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ambient atmosphere, of course, has a considerable amount of oxygen, namely approximately 20 volume percent. The sintering is effected at a temperature of approximately 1100°C.

The forgoing statement that Horikawa sinters at standard atmospheric conditions must in fact be true because Horikawa details the fact that the greenfoils are formed with the binder on the basis of polyvinyl alcohol. See example 4, column 8, line 19.

A binder of polyvinyl alcohol, in order to avoid carbon-containing remainders in the ceramic, must be debindered and sintered in an oxygen atmosphere. That is, Horikawa must utilize oxygen in order to properly remove the green foil binder.

What this also means is that the utilization of metallic copper electrodes is quite impossible in Horikawa. The use of an oxygen atmosphere during debinding and sintering at the sintering temperature of approximately 1100°C would lead to the oxidation of elemental or metallic copper into copper oxide. This, of course, would destroy the functionality of the inner electrodes in the component.



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The phase diagram shown here illustrates the balance between Cu/Cu<sub>2</sub>O which is similar to the balance between Cu/CuO. The ordinate

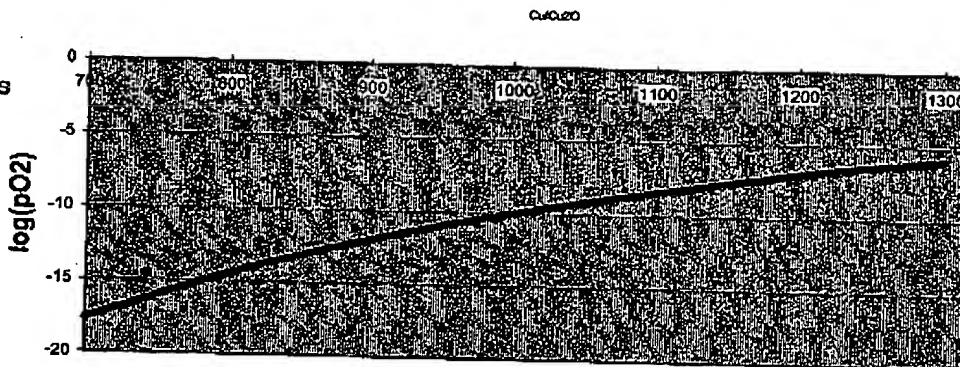
illustrates

the

oxygen

partial

pressure



measured in atmospheres and the

Temperature [K]

abscissa shows the temperature. At

— Cu/Cu<sub>2</sub>O

the temperature of approximately 1100°C (~ 827 K), therefore, an oxygen partial pressure of less than  $10^{-13}$  atm. is necessary in order to reduce Cu<sub>2</sub>O to Cu, that is, in order to obtain metallic copper. Such extremely reduced oxygen partial pressure, of course, is not possible to be had in ambient atmosphere.

Besides, Horikawa himself emphasizes the fact that the ceramic material has a component of copper oxide. See, for example, col. 8, line 19, and col. 2, line 67. The presence of copper oxide and its essential importance in the material composition of Horikawa necessarily requires that the oxygen present in the atmosphere during debinding and sintering is chosen such that the copper oxide will not be reduced to metallic or elemental copper.

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Accordingly, the phase diagram once more shows that at temperatures of about 1100°C, elemental copper and copper oxides cannot be present at the same time in thermodynamic equilibrium. Such equilibrium, of course, may be presumed because of the relatively long time periods in these processes. The disclosure in Horikawa that CuO is required in his ceramic composition, necessarily excludes the metallic and elemental copper for the inner electrodes.

It follows from the foregoing that, if one were to attempt to replace the silver/palladium inner electrodes provided by Horikawa with metallic or elemental copper, one would be faced with a problem which is impossible to solve, namely, a debinding and sintering process which at the same time does not reduce copper oxide to elemental copper and also does not oxidize the metallic copper of the inner electrodes to copper oxide. As shown, this is an impossibility in the context.

Before moving on, we must take issue with a statement by the Examiner that appears, in variations, at several position in the Office action. For instance, on page 5, bottom, the Examiner states: "Harada et al. disclose a monolithic piezoelectric part comprised of ceramic green sheets and electrodes such as copper that are sintered together to create

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the monolithic structure." This statement is clearly in error and the Examiner is respectfully urged to withdraw this statement. As previously pointed out, Harada explicitly and specifically teaches against forming ceramic green foils with electrodes but instead describes stacking sintered discs and interconnecting them with copper electrodes. While it is possible for the individual discs to be pressed together and even heated, Harada simply does not sinter the ceramic green foils together with the electrodes. Most importantly with regard to the claims, Harada does not provide a monolithic multilayer stack with internal copper electrodes.

In summary not of the references of record whether taken alone or in combination either show or suggest the features of the claims herein. All of the claims are in condition for allowance and the Examiner is respectfully urged to carefully review the above arguments and to allow the application.

In light of the advanced prosecution in this application and in light of the introduction, withdrawal, and reintroduction of the primary rejection, the Examiner is respectfully requested to telephone counsel upon having reviewed these materials so that an interview may be had. Applicants very strongly believe that the claims, as presented, are in

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condition for allowance and would, accordingly, appreciate a chance to present these arguments in person or by telephone.

In view of the foregoing, reconsideration and allowance of the claims are solicited.

Petition for extension is herewith made. The fee for response with a delay of three months in the amount of \$1020.00 is enclosed herewith.

Please charge any other fees which might be due with respect to Sections 1.16 and 1.17 to the Deposit Account of Lerner and Greenberg, P.A., No. 12-1099.

Respectfully submitted,



For Applicants

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